Throughput and Coverage Performance for IEEE 802.11ad Millimeter-Wave WPANs

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Introduction

- The 60 GHz millimeter-wave wireless technology is getting increasing attention, and several task groups are making standardization efforts;
- IEEE 802.11ad published its first draft in May 2010, and it is built on the existing WLANs, which already have a strong market presence;
- The space-time block coding (STBC) is employed to our PHY simulator to enhance the throughput and coverage.

Physical Layer Performance

The OFDM mode is designed for high performance applications on frequency selective channels. A MIMO 2×2 STBC architecture is adopted to provide transmit and receive diversity. This scheme uses a transmission matrix $[x_1, -x_2^*; x_2, x_1^*]$.

The 60 GHz channel models are generated in typical conference room scenario in both LOS and NLOS. Different degrees of correlation are considered for MIMO channel: 0.1 (low), 0.5 (medium), 0.9 (high).

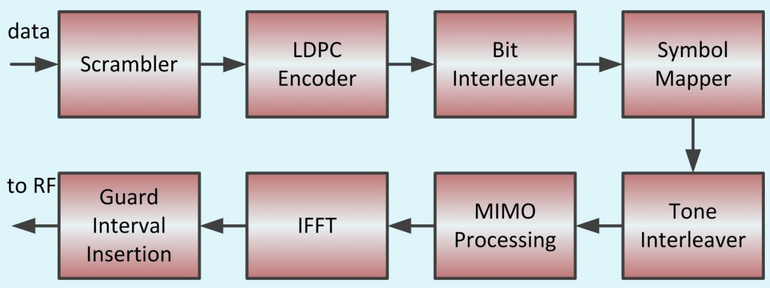


Figure 1: The block diagram of the transmitter

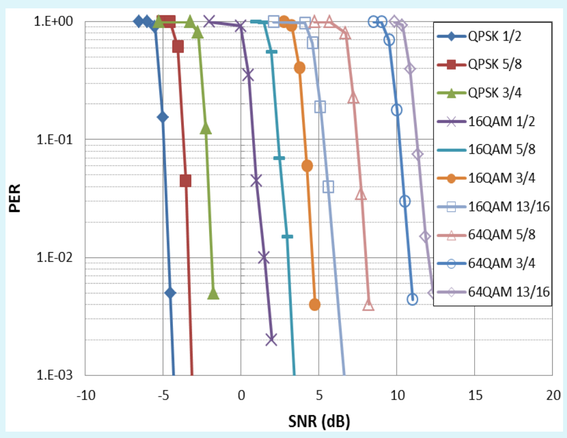


Figure 2: PER performance of STBC in LOS with high correlation.

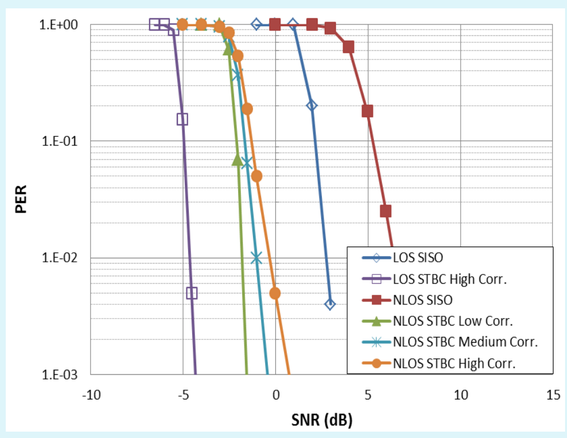


Figure 3: PER performance for QPSK ½ in different scenarios.

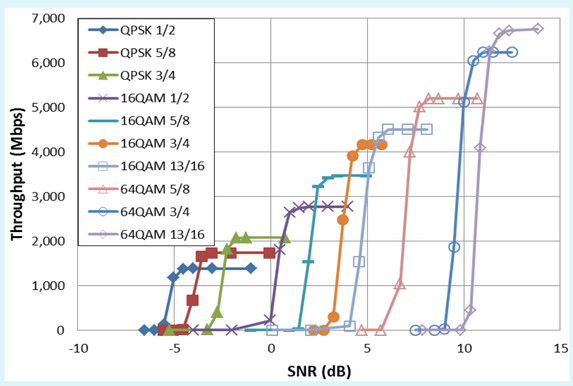


Figure 4: Link throughput of STBC with high correlation. The mode with the highest throughput is chosen for each instantaneous SNR value, and Throughput = Peak data rate × (1-PER).

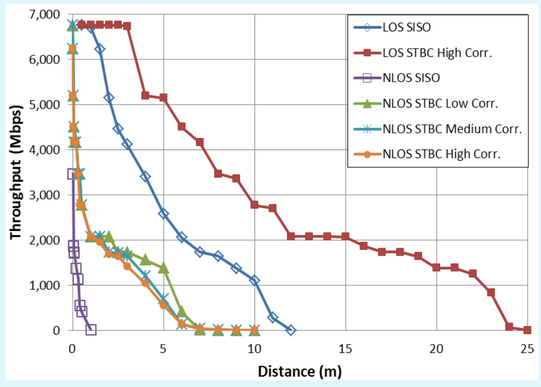
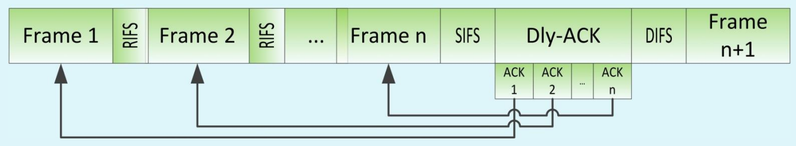


Figure 5: Maximum PHY data rate over distance in different scenarios. The STBC extends the effective transmission range with only a little additional complexity.

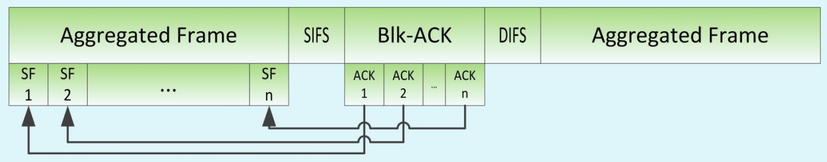
Medium Access Control Layer Performance

The MAC throughput is determined by the amount of information bits exchanged between the transceivers MAC, and the duration needed for successfully delivering the information. Sources of overhead include gap time, preamble, header, and acknowledgment (ACK) frames.

- Imm-ACK is sent out after a short inter frame space.
- Dly-ACK allows the Tx to send multiple frames, and the ACKs are grouped into a single ACK.



- Blk-ACK is used for acknowledging each subframe (SF) in the aggregated frame.



- Blk-NAK only acknowledges the error SFs in the aggregated frame.

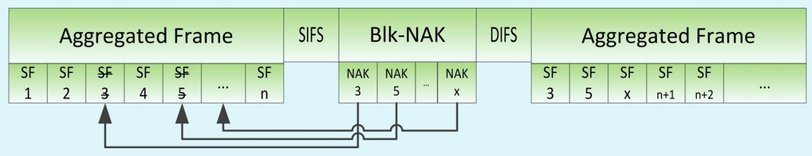


Figure 6: The operations of different acknowledgment

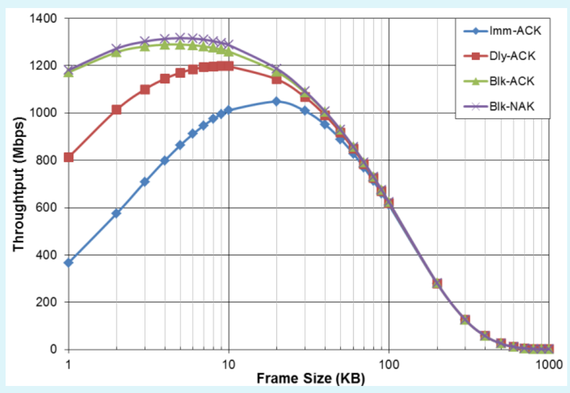


Figure 7: The maximum QPSK ½ MAC throughput for different packet sizes. The throughput increases with the frame size because a larger frame size reduces the number of inter frame space. After a certain value of frame size, the throughput decreases due to higher PER introduces increased retransmission.

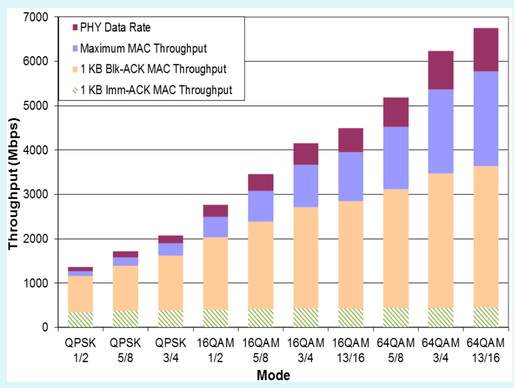


Figure 8: The maximum MAC throughput achieved by each mode. The Imm-ACK does not have payload, so the throughput does not depend on the PHY mode significantly. The higher modes are affected more by Blk-ACK, because the inter frame space takes higher ratio in transmission time.

Conclusion

- Applying MIMO 2×2 STBC can maintain the high peak throughput and also enhance the transmission coverage significantly;
- Frame aggregation and Blk-ACK / Blk-NAK could increase the MAC throughput greatly;
- The maximum MAC throughput decreases due to the overheads, but can be improved by choosing an optimum PHY packet size.

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